University of Zurich[UZH]

Zurich Open Repository and Archive
University of Zurich
University Library
Strickhofstrasse 39
CH-8057 Zurich
www.zora.uzh.ch

Year: 2018

Recommended standards for conducting and reporting ethnopharmacological field studies

Weckerle, Caroline S ; de Boer, Hugo J ; Puri, Rajindra K ; van Andel, Tinde ; Bussmann, Rainer W ; Leonti, Marco

DOI: https://doi.org/10.1016/j.jep.2017.08.018

Posted at the Zurich Open Repository and Archive, University of Zurich
ZORA URL: https://doi.org/10.5167/uzh-139153
Journal Article
Accepted Version

The following work is licensed under a Creative Commons: Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) License.

Originally published at:
Weckerle, Caroline S; de Boer, Hugo J; Puri, Rajindra K; van Andel, Tinde; Bussmann, Rainer W; Leonti, Marco (2018). Recommended standards for conducting and reporting ethnopharmacological field studies. Journal of Ethnopharmacology, 210:125-132.
DOI: https://doi.org/10.1016/j.jep.2017.08.018

Author's Accepted Manuscript

Recommended standards for conducting and reporting ethnopharmacological field studies

Caroline S. Weckerle, Hugo J. de Boer, Rajindra K. Puri, Tinde van Andel, Rainer W. Bussmann, Marco Leonti

www.elsevier.com/locate/jep

PII: S0378-8741(17)31632-X
DOI: http://dx.doi.org/10.1016/j.jep.2017.08.018
Reference: JEP10988

To appear in: *Journal of Ethnopharmacology*

Received date: 21 April 2017
Revised date: 20 July 2017
Accepted date: 12 August 2017

Cite this article as: Caroline S. Weckerle, Hugo J. de Boer, Rajindra K. Puri, Tinde van Andel, Rainer W. Bussmann and Marco Leonti, Recommended standards for conducting and reporting ethnopharmacological field studies, *Journal of Ethnopharmacology,* http://dx.doi.org/10.1016/j.jep.2017.08.018

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting galley proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ACCEPTED MANUSCRIPT

Recommended standards for conducting and reporting ethnopharmacological field studies

Caroline S. Weckerle[1], Hugo J. de Boer[2,3], Rajindra K. Puri[4], Tinde van Andel[5,6], Rainer W. Bussmann[7], Marco Leonti[8]*

[1]Institute of Systematic and Evolutionary Botany, University of Zürich, 8008 Zürich, Switzerland;
[2]Natural History Museum, University of Oslo, 0318 Oslo, Norway;
[3]Department of Organismal Biology, Uppsala University, Uppsala, Sweden;
[4]Centre for Biocultural Diversity, School of Anthropology and Conservation, University of Kent, Canterbury, CT2 7NR. United Kingdom;
[5]Naturalis Biodiversity Center, Darwinweg 2, 2333 CR Leiden, The Netherlands;
[6]Wageningen University and Research, Wageningen, The Netherlands;
[7]William L. Brown Center, Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166-0299, USA;
[8]Department of Biomedical Sciences, University of Cagliari, Via Ospedale 72, 09124 Cagliari, Italy.

*Corresponding author, Tel.: +390706758712; fax: +390706758553
E-mail addresses: marcoleonti@netscape.net; mleonti@unica.it

Accepted manuscript

Abstract

Ethnopharmacological relevance:
What are the minimum methodological and conceptual requirements for an ethnopharmacological field study? How can the results of ethnopharmacological field studies be reported so that researchers with different backgrounds can draw on the results and develop new research questions and projects? And how should these field data be presented to get accepted in a scientific journal such as the Journal of Ethnopharmacology? The objective of this commentary is to create a reference that covers the basic standards necessary during planning, conducting and reporting of field research.
Materials and methods: We focus on conducting and reporting ethnopharmacological field studies on medicinal plants or *materia medica* and associated knowledge of a specific people or region.
The article highlights the most frequent problems and pitfalls, and draws on published literature, fieldwork experience, and extensive insights from peer-review of field studies.
Results: Research needs to be ethical and legal, and follow local and national regulations. Primary ethnopharmacological field data need to be collected and presented in a transparent and comprehensible way. In short this includes: 1) Relevant and concise research questions, 2) Thorough literature study encompassing all available information on the study site from different disciplines, 3) Appropriate methods to answer the research questions, 4) Proper plant use documentation, unambiguously linked to voucher

specimens, and 5) Qualitative and quantitative analyses of the collected data, the latter relying on use-reports as basic units.
Conclusion: Although not exhaustive, we provide an overview of the necessary main issues to consider for field research and data reporting including a list of minimal standards and recommendations for best practices. For methodological details and how to correctly apply specific methods, we refer to further reading of suggested textbooks and methods manuals.

Graphical Abstract

Keywords: Methods, Ethnobotany, Ethnopharmacology, Standards, Field research, Traditional medicine

1. Introduction

In spite of the Journal of Ethnopharmacology (JEP) having established the "Rules of 5": https://www.elsevier.com/__data/promis_misc/jeprulesof5.pdf) as well as a journal checklist to be completed upon submission (https://www.elsevier.com/__data/promis_misc/JEP_AuthorChecklist.pdf), which should help to guarantee a minimum standard of the submitted studies, from a reviewers' perspective, too many manuscripts are rejected because they lack minimal standards of field research and data presentation. This is a regrettable situation considering the time spent by researchers and the potentially valuable data being lost.

With respect to field studies, the Rules of 5 state that "ethnopharmacological and ethnobotanical surveys normally need to report primary (absolute) data reporting how many times a (botanical) drug has been cited for a certain use and application". The journal checklist additionally asks: "Have you provided absolute/primary data on the frequency of plant use as mentioned in the interviews? And is there a critical assessment of the traditional uses considering regional and global uses and known scientific information on the chemistry and biological effects?" and "Have you provided full botanical plant names, including authorities of all plants?".

The objective of this commentary is to create a reference explaining the rules of 5 in more detail concluding with bullet points in the form of "minimal standards" and "recommendations" addressing some of the more frequent issues encountered in submitted manuscripts. It is not intended as a methods manual, but rather to communicate lessons learned by a group of researchers and insights obtained by acting as referees to pinpoint potential pitfalls during planning, conducting and analysing field research. While complementary to the consensus statement on ethnopharmacological field studies (ConSEFS) (see Heinrich et al., 2017) this article is more specific to the requirements of the Journal of Ethnopharmacology and goes more into details.

In addition to key texts in research methods (e.g., Bernard 2011; Newing 2011) various ethnobotany methods manuals are available that can be consulted (e.g., Martin, 1995; Alexiades, 1996; Cotton, 1996; Cunningham, 2001). Also several influential papers have been published on standards in the field of ethnopharmacology (Berlin and Berlin, 2005; McClatchey, 2006; Gertsch. 2009; Heinrich et al., 2009) and many good examples of published field research exist.

2. Why do research?

Often, the expressed rationale for ethnopharmacological studies is that no previous research has been conducted in a specific location or among those specific people. This is a valid argument that satisfies a curiosity-driven need to document traditional knowledge. However, such a rationale should at least specify why this area or those people are of interest and relevant for the specific research question. Studies should not only be descriptive, but rather address specific research questions and testable hypotheses, and contribute to disciplinary debates and conceptual frameworks that can advance the field and relate to contemporary issues in both scientific and public spheres (see also Heinrich et al., 2009).

Accepted manuscript

Similar critiques can be raised of another common rationale for ethnopharmacological research, given in both rejected and accepted papers, that “80% of the people in developing countries use traditional medicine as their primary source of healthcare”. Apart from the fact that this statement is unsubstantiated[1], such a general proposition can only justify research to test its claim, or perhaps underpin a generic disciplinary aim of studies of traditional medicine, but otherwise offers no theoretical motivation for any particular ethnopharmacological study.

Frequently, studies refer to the need to document traditional herbal knowledge to foster local health care, save it for future generations, as well as for potential drug discovery. However, the paradigm that ethnopharmacological research is still of significant relevance to conventional drug discovery has been challenged (Gertsch, 2009). Several studies have pointed out the dynamic character of traditional medical knowledge, and argued that acculturation and globalization is not a priori detrimental but rather that amalgamation of traditional with new knowledge systems can help people to adapt to new realities. Ethnopharmacology should clearly address its significance for those outside the academic community and research should be based on a partnership with local participants. It is meaningful to consider together with the participants how ethnopharmacological studies can contribute to for example livelihood improvement and how useful information can be exchanged (e.g., Jäger, 2005). Indeed, with the recent development of institutional codes of ethics, especially with regard to Free Prior Informed Consent (FPIC; e.g., ISE 2006), and the requirements of both national research regulatory agencies and international agreements (e.g., Convention on Biological Diversity, 1992; CBD Nagoya Protocol on Access and Benefit Sharing, 2014), almost all field research in ethnopharmacology and ethnobotany must be supported by research agreements that specify means for dissemination of research results, outreach to participants, and even potential benefit sharing arrangements (e.g. Gamborg et al., 2012).

Based on the above, scholars in ethnopharmacology need to critically consider the importance of their research: Given the global base of conducted ethnopharmacological field studies, what kind of new information do we hope to retrieve? In which way are these studies going to contribute to the scientific understanding of traditional medicine and herbal drugs? How does our research contribute to cultural documentation and improve the livelihoods of local participants?

Accepted Manuscript

3. Research Questions

All effective and significant research is guided by research questions that potentially provide answers that close gaps in knowledge. However, meaningful research questions and relevant ethnomedical information or quantitative analyses leading to the interpretation of the traditional health care

[1] Attributed to the World Health Organization (WHO Fact Sheet 134 of 2003) but currently not being promoted in the latest Traditional Medicine Strategy of the WHO (WHO, 2013).

situation are often lacking in the manuscripts submitted to JEP. On the other hand, the general push of journals for quantitative studies often results in the uncritical use of all kinds of indices.
While the guiding and inherent question of most ethnopharmacological field studies is “What plants do people use as medicine?” it would be important that contemporary research goes beyond this fundamental knowledge and develops additional questions or tests derived hypotheses. For instance, “Why is plant species X used for so many diseases? Why are so many plant species used for one particular disease?” In Sub-Sahara Africa, for example, one of the major use categories in the trade in herbal medicine (in both number of species and volumes sold) is female reproductive health (Van Andel et al., 2012; Towns et al., 2014). This observed phenomenon almost automatically leads to several hypotheses:

1) Women probably have limited access to modern medicine
2) Women prefer plants to treat reproductive ailments
3) Women need plants for certain aspects of reproductive health that modern medicine cannot offer them (e.g., abortifacients).

Such hypotheses can be tested by including questions about these subjects in interviews (for example, asking female customers for their motivation to use herbs) and by collecting data on national reproductive health statistics. In anthropological papers, one can retrieve information on the local aetiology of illnesses that are often treated with traditional medicine. In this way the data from ethnopharmacological surveys can be contextualized, which makes the research much more interesting to public health authorities and medical anthropologists than just a list of plants and their uses.
Research questions should be clearly and concisely written, focused on descriptive as well as explanatory objectives (e.g., *When do residents avoid government health clinics?*) that illuminate the relationships between concepts or categories associated with the topic of interest. Research questions are ultimately non-trivial if they lead to answers that contribute to knowledge production, advancement of the discipline, and/or solve problems, as discussed above. It is helpful to develop site selection criteria that set out the optimal characteristics desired for a particular location to pursue the research questions. This is especially important when planning comparative studies where it is necessary to control for variation in a limited number of variables among sites in order to test hypotheses.
It is expected that research proposals or manuscripts clearly state their research questions and how these were derived in an introduction. The rest of the manuscript will follow from these questions. Submitted manuscripts are often too long because the authors do not keep themselves to specific questions and hypotheses. Posing research questions and hypotheses helps to maintain order in the manuscript, and identify those issues and data that are relevant.

4. Methods
In this section, we analyse some of the main problems in using and reporting research methods in ethnopharmacological research.

Accepted manuscript

4.1. Selection and description of study site and participants

A description of the available local health care providers contextualizes the use of traditional medicine. Along with the overall health care options, the epidemiologic and ethnographic background and the rationale of people's health seeking behaviour can be put into perspective, and accommodate the research questions.

Ethnographic details of the study's local participants complement the scientific rationale, which lead to the selection of the study site. Historical, economic, political, social and cultural characteristics may be key variables, and details of these aspects should be included for the investigative framework. Additionally information including references providing further detail to the biome, the climatic conditions and the geography can help to contextualize the study, and these should be provided. Here it is important to avoid referring to compilation websites, but cite specific objective sources for all information. In cases where respondents do not want their location to be published, or researchers fear potential harm to their respondents for participating in the research, pseudonyms can be used and any maps need to be of sufficiently large scale to prevent identification of study sites. Non-disclosure of such information must be well motivated in the manuscript.

4.2. Selection and description of respondents

Depending on if the study focuses on the general knowledge of a population or on specialists' knowledge the sampling strategies and the number of included participants differ (Bernard 2011; Newing, 2011). Of particular relevance here are several social characteristics of ethnomedical systems that have a bearing on sampling (see Zent and Maffi, 2008). It is already known that knowledge and use of medicinal plants, for instance, is gendered (Howard, 2003; Pfeiffer and Butz, 2005), and that knowledge is differentiated by age, with younger people generally knowing less than elders. This can be even more pronounced when levels of education are factored in, whereby formal schooling, even close to home, may influence a child's acquisition of traditional knowledge (Reyes-Garcia, 2013). Typically, there is also a distinction between generalist and specialist knowledge, whereby the general populace normally has a lower level of knowledge, while specialist healers, herbalists, doctors or shamans hold the bulk of medicinal plant knowledge as well as comprehension of the ethnomedical system. Where plant collecting is a distinct occupation or a specified social role, we can expect plant collectors, or traders, to have different knowledge compared to those specialists that make, sell (pharmacists, market vendors) and administer medicines (healers, doctors). Similarly social class, caste and religion may also create variation. Social segmentation means that knowledge and use of medicinal plants varies across all study populations, and in fact, the relationship between knowledge and practice may also vary, whereby younger people may know of plants and their uses, but be less skilled in identifying drugs or compound medicines. This shift from substantive to more theoretical knowledge of traditional medical systems is an important subject for contemporary research (Zent and Maffi, 2008; Reyes Garcia et al., 2009; Puri, 2013). Therefore, selecting participants for research should consider this complex variation and explain why certain groups of the population were included and others not.

Accepted manuscript

Another sampling choice is the unit of analysis, and individuals, households, communities or language groups may be sampled. Common errors in analysis are overgeneralizations of results to a much larger population than sampled. Likewise one cannot speak of individual variation when data was collected in focus groups or community meetings. However, if you wish to use quantitative analyses, make sure you have a sample that is sufficiently representative to test your hypotheses. The best way to achieve this is to consult specific literature (e.g. Kadam and Bhalerao, 2010; Bernard, 2011) or a statistician before you start sampling.

To analyse collected data from respondents, and to write a proper methods section in a research paper, information about the interviewed people needs to be recorded. This can be presented in a summary table or an appendix, and includes as a minimum, and in an anonymised form, sex and age of the respondents. Usually, information about ethnicity, religion, primary and interview language, literacy and schooling, and occupation of respondents is collected too, and, if appropriate, marital status and family size depending on the necessities of the specific project.

4.3. Duration of thorough field research

The ideal field study would last more than a year, to capture the full floral, agricultural and cultural cycle. There may be seasonal differences in both illnesses and the availability of plant remedies and this may affect the way respondents discuss these topics. Markets also vary by season, so inventories and interviews with both sellers and consumers should be repeated to capture this variation. Given the interdisciplinary nature of research, bringing in specialist experts, botanist or medical doctors for instance, might help to enrich or facilitate data gathering. Botanists may be able to identify sterile specimens in the field, doctors may help understand local medical systems and veterinarians may help understand local animal illnesses. Another solution, in certain circumstances, may be to train local participants as interviewers or plant collectors to increase the sample set in the given time period. Key here is to realize the limitations of a study covering less than a full year, and to discuss them in the manuscript.

Similarly, if the research project and the local situation allows, it might be good practice to document the whole *materia medica* or medicinal flora of a community or a population, not just parts thereof. This also includes contextual aspects such as the relationship between people and the medicinal plants. While scientists tend to see plants as “natural resources”, for local participants they may be living organisms, which are part of an intricate kinship network.

The overall profile of a plant’s use(s) gives important information (including local respondents’ rationales) for further (ethnopharmacological) research, while focusing on specific diseases and ailments bears the risk of decontextualizing plant use and ethnopharmacology in general. Exceptions are treatment outcome studies, which need to focus on a specific health condition or disease (e.g., Willcox et al., 2011). If a field study does focus on specific therapeutic uses, a sound scientific motivation or a reason related to pressing health issues should be evidenced, while the reported data is expected to be comprehensive. Most manuscripts submitted to JEP focusing on a specific ailment or disease group do so without any particular scientific

Accepted manuscript

motivation. Publishing subsets of field data causes unnecessary fragmentation and risks distorting research results, while more comprehensive papers are often more valuable for future research.

4.4. Collecting Plants

The challenge during ethnopharmacological field research is to link collected local plant names with plant samples (Rivera et al. 2014; Bennett and Balick, 2014). Ideally, one should collect voucher specimens with each respondent for all plants mentioned during interviews. Studies need to report the means and sources of plant identification, the institutions holding the voucher specimens, and the experts that have helped to identify these samples. Some challenges in terms of scientific rigor that scholars in ethnopharmacology face are: 1) Collection of complete specimens for herbarium vouchers; 2) Linking names mentioned during interviews to plants collected during subsequent voucher collecting; 3) Exhaustive collection of vouchers for ethnotaxa; 4) Use of visual aids for identification; 5) Depositing ethnobotanical voucher specimens as herbarium vouchers and their retrieval; and 6) Identifying and applying accepted scientific names.

For some regions field guides for sterile plant material exist (e.g., Gentry 1993). Otherwise, one may try to augment sterile material, for example, with old fruits lying on the floor below the plant collected or germinated seedlings with seeds attached. They can be dried and included, but labels must specify this, e.g., "old fruits collected from forest floor". Also, local guides can be asked to describe the flowers and fruits of the collected plant. Again, voucher labels should record this as, for instance, "fruits are said to be flat and as big as a machete". These clues can aid identification later on, even though the collector has not observed them. For details on how to collect herbarium specimens we refer to the Herbarium Handbook (Bridson and Forman, 2013).

Linking local plant names to taxonomically accurate botanical taxa is essential to ethnopharmacological research. A key issue in this regard is the under- or over differentiation of ethnotaxa in comparison to Linnaean binomial nomenclature, such as species referring to several ethnotaxa and vice versa. It is therefore important to collect voucher specimens on site with all interview partners and ask about possible ethnobotanical ambiguities (Berlin, 1973). In addition it is important to use currently accepted names and author abbreviations when referring to scientific taxa. Cross-referencing names found in local floras with more versatile online databases, such as the Medicinal Plant Names Services Portal (http://mpns.kew.org/mpns-portal) or The Plant List (http://www.theplantlist.org/), is necessary to avoid using older synonyms.

The use of pictures should always be avoided to elicit initial responses, and visual aids in general should only be used to disambiguate. Authors are, however, encouraged to provide links to high resolution scans of the herbarium vouchers in either the main manuscript or as supplementary data. These should be fully curated specimens with databased voucher information. These scans should be stored in permanent digital resources independent of the journal. This enables identification of the vouchers by other people than the authors or specialists working in that herbarium. In addition, digital photographs taken of living material in the field can be included to strengthen the botanical value of the paper. In this case, these should be deposited in

Accepted Manuscript

independent digital data repositories that provide digital object identifiers (DOI), such as DRYAD (https://datadryad.org/).

5. Data handling, systematization and presentation

All research articles should describe their methods used to allow others to replicate the study as far as possible. This applies to the gathering of the original primary data collected for answering specific research questions, as well as to the data analysis tools (e.g. Verpoorte, 2012; Baker, 2016).
The cultural context of plant use can generally be well addressed with qualitative data while the frequency of specific actions can be measured with quantitative data (Bernard, 2011). Therefore, they complement each other and may result in a presentation of ethnopharmacological field data (mostly quantitative) in its sociocultural context (mostly qualitative) highlighting the role of ethnomedicine among local health care options.

5.1. Qualitative data

Qualitative data can be obtained through direct observations (so-called participant observation; for details and challenges see Bernard (2011) and Newing (2011)) as well as interviews, and is descriptive. The description of an ethnomedical or local medical system with its different types of healers, health care facilities, emic/local disease aetiologies and categories is usually presented qualitatively. The explanations given by the healers regarding the healing properties of the applied remedies is the kind of information that helps the researcher to understand emic healing concepts. Also reporting names of medicinal plants, descriptions of processes such as the precise preparation of medicines (recipes) and the prearrangement for a ceremony calls for a qualitative approach.
During data analysis qualitative data are often organized, e.g., through categorizing descriptions of sickness, into emic or biomedical categories of use for the assignment of use reports (quantitative data). The methods section of any paper should explain how the collected data is being quantified and which criteria were used to categorize emic descriptions of sickness (e.g., Berlin and Berlin, 1996; Staub et al., 2015). As already mentioned above, categories of use are important for descriptive statistics, for quantitative analysis and cross-cultural comparisons (Leonti and Weckerle, 2015). They arrange specific health conditions and symptoms into more or less well defined groups of therapeutic domains (e.g., skin, digestive, neurological, psychological).
What becomes apparent when reviewing or reading ethnopharmacological studies is that researchers often report their own interpretation of ailments reported by healers and, additionally, categorise them according to etic criteria. For instance, vague terms such as “bellyache” are translated as "gastro-intestinal disorders", "colics" or "appendicitis", or even more specific medical terms such as gastrointestinal inflammation. Emic categories can be investigated by using a combination of freelisting and pile sorting (Bernard, 2011; Puri, 2011). Most traditional healers do not have the necessary background to diagnose all ailments properly, and may not use biomedical terms at all. As long as not medically trained personnel diagnose patients in

Accepted manuscript

the field, the International Classification of Diseases (ICD) by the WHO or the 'Economic Botany Data Collection Standard' by Cook (1995) cannot be meaningfully applied for the classification of remedies, ailments and diseases reported by local participants. An alternative classification system accepted by the WHO is the ICPC (International Classification of Primary Care). This system is used in general family practice and primary care allowing "classification of the patient's reason for encounter" (http://www.who.int/classifications/icd/adaptations/icpc2/en/) and can therefore reasonably be applied to collected ethnomedical data for comparative purposes (Staub et al., 2015).
One needs, however, to consider that patients can get their diagnosis from trained physicians and/or outpost clinics and subsequently ask for a remedy from a local healer or herbalist. Also therefore, background information about the local health care facilities (biomedical and alternative medicine) and peoples' attitudes towards choosing their medicine should be provided in a manuscript. Other qualitative data important for contextualizing quantitative field-data is information about the origin of medical knowledge and knowledge transmission in general. While not all researchers will be interested in the history or the transmission of ethnomedical knowledge, asking respondents from where or whom they acquired their knowledge is increasingly seen as important given the increased access people have to media and other information technology, as well as the long histories of contact and exchange (pre-colonial and colonial) in most parts of the world.
For the different types of qualitative and quantitative analysis we refer to Bernard (2011).

5.2. Quantitative data

Quantitative data are amenable to statistical manipulation and analysis. Identifying drugs or remedies that are most heavily relied upon (most frequently mentioned is then often used as a proxy) for a certain ailment or disease category are among the most common research goals of ethnopharmacological field studies. Important key data are the number of local participants that were interviewed during a survey. The frequency of citation of a specific remedy, that is, the number of individual use-reports (n_{ur}) for a type of drug and its therapeutic application, serves to establish the consensus across the respondents. The cultural consensus on healing properties of remedies and drugs can help to inform subsequent laboratory studies that aim at evaluating their efficacy and toxicology (Trotter and Logan, 1986; Berlin and Berlin, 2005; Heinrich et al., 2009).
Primary data is usually presented in the form of use-reports. A use-report can be defined as an individual report of a specific taxon/drug for a certain category of use, a specific ailment, disease or symptom. However, use-reports can be defined differently and therefore it is important to give a working definition.
Differentiating use-reports by the level of specific diseases, ailments or symptoms, and considering the kind of drug used (e.g., root, seeds, herb, bark), will result in more detailed use-reports with lower frequencies and render downstream analysis more complex. Additionally, other variables contained in a recipe can be considered in the definition of a use-report,

Accepted manuscript

including different modes of preparation (e.g., infusion, cataplasm, bath) and application (internal, external, fumigation, enema). However, since plant-based remedies are often used for many specific conditions within the same category of use, and since different parts of the same taxon can often be applied interchangeably, it normally makes sense to define a use-report through the local participant, the category of use and the taxon.
The first step of data analysis usually consists in the quantitative evaluation of use-reports assigned to emic categories of use. For plant species that are common in mixtures, more use-reports are usually collected, and this may result in over-emphasizing of those categories of use containing many components of drug mixtures. Also, if a drug's uses are counted separately for every specific ailment (e.g., dermatologic problems: pimples, pustules, acne, shingles, wounds, eczema, etc.) the importance of use categories encompassing many distinguishable ailments will be further emphasized or inflated. Generally it is convenient to keep the definition as basic as possible but this depends on the specific research question.

5.3. Presentation of data

As an interdisciplinary field of research providing primary data and a scientific nexus with disparate research projects as well as scientists with different training backgrounds, it is important that ethnopharmacological field data is presented as intuitively and straightforward as possible. The collected primary data should be presented in a genuine and unaltered form, which allows the scientific community to use these raw data for different approaches and interpretations. Such 'raw data' presentation also facilitates reproducibility and guarantees transparency. For ethnopharmacological field studies this implies that the emic, or local description of a remedy's use is reported and differentiated from the researcher's (etic) interpretations presented in the discussion of the data (Headland, 1990; Leonti and Weckerle, 2015).
Usually the quantitative primary data or raw data obtained through ethnopharmacological field studies is presented in table format embedded in the research article or made available in the appendix or as supplementary data. It is useful to follow a table structure where the rows are associated with either ethnotaxa or plant taxa and the columns with the specific associated information:

1. Plant name: Scientific binomial name including abbreviated author name
2. Plant family: Follows the most recent classification
3. Vernacular name in the primary language (indicated) by the local participants
4. Vernacular name in official language in region, country
5. Herbarium voucher number (collector or code and collection number)
6. Uses: Use-category (emic or etic) followed by (n_{ur}) and specific uses followed by (n_{ur}); other use-category (n_{ur}) [and continued in this vein]
7. Drug: Plant parts used per use-category and specific uses with (n_{ur})
8. Preparation per use-category and specific uses with (n_{ur})
9. Mode of application per use-category and specific uses with (n_{ur})
10. Healing virtue: Emic rational (e.g. hot/cold, organoleptic property)

Accepted manuscript

5.4. Quantification of use-reports and transformation of primary data

If one writes that out of 100 local participants 50 report using the inflorescence of Chamomile (*Matricaria chamomilla* L.) in the form of an infusion to treat bellyache in general, 15 to treat flatulence, 10 to treat gastritis, 50 to treat nervousness, and another 30 to treat menstrual problems, whereas 25 use the essential oils to treat skin conditions such as eczema, then researchers from all backgrounds will get an idea about the pattern of variation regarding the medical use of this plant. Such a quantification of anecdotal reports about the use or effectiveness of remedies in relation to the absolute number of participants interviewed can guide the selection of plant compounds for experimental studies (Trotter and Logan, 1986).

The results of ethnopharmacological field research are often quantified in the form of indices, e.g., cultural value, fidelity level, relative importance, use value, local participants agreement ratio or relative frequency of citation (see Dudney et al. (2015) for a comparative analysis of such indices). A key issue of such indices is that they are difficult to interpret and compare, especially when different uses, often also including non-medicinal uses, are subsumed within the same index, e.g. "the relative frequency of citation of *Matricaria chamomilla* is 0.85, the fidelity level is 80% and the use value 1.15".

It also seems that the most widely applied indices are not very specific, as the produced values seem to correlate across formulas, while the design of the study, especially the selection of the participants, can have a pronounced impact on the values (Dudney et al., 2015). In addition to the limited relevance of these indices for readers, their statistical value is questionable, as they do not consider variance of the data[2].

Moreover, the concepts of "importance" and "value" are context dependent and subjective, and render indices used to describe the significance of traditional drug use problematic. They may also be misleading: An effective cure used for a rare and severe disease might get fewer citations by a local population than a remedy used for frequent ailments, but this does not automatically imply that the former has less value to these people. Since ethnobotanical indices are frequently presented instead of primary data, often without referring to specific therapeutic applications and moreover ignoring the uncertainty around sampled data, their application has resulted in many studies that are difficult to comprehend.

[2] Common to all these indices is the lack of a measure for the probability distribution, e.g. the variance of the data, which also precludes these indices from being compared to other studies. In statistics, equal proportions, such as five out of ten (5/10) (e.g., five respondents out of ten mentioned the same use), twenty-five out of fifty (25/50) or fifty out of hundred (50/100), are not the same thing because of the different variance surrounding these data. Given a certain proportion p, its standard deviation is the square-root (SQRT) of (p(1-p)/N), where N is the sample size used to calculate p and the denominator of the fraction. Using the central limit theorem the true proportion lies within $p \pm 1.96 \times SQRT(p(1-p)/N)$ with a probability of 95%. In practice the difference between proportions can be claimed with a certain probability when their respective intervals do not overlap (e.g., Watt et al. 2007).
The same is true for the Jaccard index (JI = (c/a+b+c) x 100), which derives from community ecology and is occasionally used for assessing the similarity of pharmacopoeias and medical floras. Imagine two datasets (medicinal flora or therapeutic uses) with sample a=100 and sample b=100 and an overlap of c=50. While the JI delivers a similarity index of 33.3%, the actual overlap is 50%.

In the form that ethnobotanical indices are currently applied they are not amenable to comparative ethnopharmacology, meta-analysis or hypothesis testing. The statistical power might rise if different formulas are adapted to include variance and when they refer to specific categories of use or applications[2]. However, when the primary data is presented in a transparent way anyone can theoretically use that data to calculate any indices he/she might wish to, and thus manuscripts should ensure accessibility to the primary data.

6. Research permits and ethics

Research permits and ethical issues are the two single most important aspects that can lead to the rejection of even scientifically brilliant papers. Until the last decade of the 20th century, ethnobiological research was little regulated on a global scale, and even the collection of biological materials was governed by few restrictions other than the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), and import regulations of many countries that required a Phytosanitary Certificate that would certify that biological material was not carrying any disease agents. This practice changed with the Convention on Biological Diversity (CBD) coming into effect in 1992, and, especially from the perspective of ethnobiological research, with the coming into effect of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (Nagoya Protocol) in 2014, although the USA for example has not ratified either treaty, and many countries have not yet ratified the Nagoya Protocol.

The CBD for the first time assigned genetic resources as property to national states. Based on this guideline, all signatory countries (at present 196) were required to develop legislation to implement the CBD, including legislation on regulating collection and export of biological material. The provision declared in article 8(j) of the CBD had very little effect in practical research, because access to knowledge basically remained unregulated. This changed entirely with the Nagoya Protocol (now ratified by 76 countries).

The Nagoya Protocol clearly assigns the property rights of traditional knowledge to the respective knowledge holders. The main objective of the protocol is "*the fair and equitable sharing of benefits arising from the utilization of genetic resources...*" including that "*traditional knowledge associated with genetic resources held by indigenous and local communities is accessed with the prior and informed consent or approval and involvement of these indigenous and local communities and that mutually agreed terms have been established. Any community work is performed under the Nagoya Protocol on Access to Genetic Resources and Equitable distribution of benefits from their use, and that the right of use and ownership of any traditional knowledge of all informants remains with them, and that any use of the information except for scientific publication, requires the additional consent of the traditional owners, and consensus on access to benefits derived possibly later use.*" (CBD, Nagoya Protocol 2014). These treaties have several implications for research ethics and permits.

6.1. Ethics

Accepted manuscript

Ethical research, in all cases, is research that does not negatively impacts participants of the research. Ethnopharmacological research often takes place among marginalized people, and working with them on an equal partnership basis and empowering them through collaboration and exchange is essential in participatory research. Researchers also need to be sensitive both during research and when presenting their data to not imply that local knowledge is somehow inferior to scientific knowledge. In many cases, authors of scientific papers regard local counterparts simply as “informants” or “study subjects”, whereas their contributions should be fully acknowledged through co-authorship or duly acknowledged in the appropriate section of the paper. Similarly, local knowledge documented during research, as well as its further implications and use, are often regarded as the property of the researchers or scientific institutions involved, but this is an outdated view on research. Researchers should consider beyond the legally binding regulations for research permits what impact their research may have on local people’s rights, livelihoods and culture. For details on intellectual property rights issues we refer to the ‘World Intellectual Property Organization (WIPO) TK Documentation Toolkit’ (https://www.cbd.int/tk/wipo.shtml).

Ethnopharmacological field research should always include clear arrangements with local counterparts and legal entities, even though official regulations might not exist. After implementation of the CBD, many research institutions around the globe set up “Internal Review Boards (IRB)” to screen research proposals involving human “subjects.” At the very least, any paper should include written evidence or a reference number of such ethical approvals, provided the institutions of the authors have such a board. However, based on the stipulations of the Nagoya Protocol, a simple “ethics approval” by a researcher’s IRB is not sufficient to allow publication. Many journals do, in fact, require additional written evidence that local law, as well as community regulations were followed. In the former case, a research permit number, or an indication which entity granted the permit to do research, should be provided. In case of the latter, an indication of how permits from local and indigenous communities or participants were obtained should be included.

Normally, information on Free Prior Informed Consent (FPIC) is required for any publication. The concept of FPIC is, however, problematic for two reasons: On the one hand, many journals are not content with oral FPIC, as practiced, especially in ethnobiological studies. On the other hand, in many research settings, a request for written FPIC creates distrust among participants, because signing papers is simply not common, and the content of a FPIC disclosure might be hard to understand. Under such circumstances, the best choice for researchers is to provide a statement on what kind of FPIC they obtained, and to state if they followed a specific code of ethics. For ethnobiological research, the current standard is the International Society of Ethnobiology (ISE) Code of Ethics (ISE 2006).

It should be noted that under the Nagoya Protocol, FPIC does not only refer to consent from community leaders, but from each individual participant in the research. In addition, it has to include arrangements about benefit-sharing, as well as recognition of the intellectual property rights of the respective participants and their communities. While not all countries have ratified the Nagoya Protocol, most, especially Western, researchers are bound by it.

Accepted manuscript

Researchers working in the European Union for example are legally required to comply with the Nagoya Protocol, because the EU has ratified it. While the USA has not ratified the Nagoya Protocol, US researchers are still required to comply with it when it comes to the import of biological material and associated knowledge.

6.2. Research permits

The lack of appropriate research permits might provide a similar reason to reject a paper. Based on the CBD, most countries require researchers to obtain clear permits for the collection of biological specimens. Such permits normally state explicitly where collections can be done, what can be collected, and how many samples (or duplicates) are permitted. In most cases a research permit will also stipulate where the collection has to be deposited (generally half of all individual specimens, as well as unicates and types are to be deposited in the host country). Export of specimens normally requires that researchers prove that the required material has been deposited at a national institution in the host country. Both research and export permits are, in most cases, required to legally import material into any country a researcher might reside in. After the ratification of the Nagoya Protocol, most host countries require additional permits for studies involving traditional knowledge. Generally, a written permit from local or community councils or similar entities is required, before a research permit will be issued by the respective National Focal Point. It is important to note that the community permit does also need to be based on FPIC, and does have to include any stipulation on benefit-sharing, intellectual property rights (for example stipulation on whether or not participants will be named as authors), and any wording related to possible future use of such knowledge.

7. Conclusions

We conclude this commentary with a bullet list of minimal standards and recommended practices, which we condense from the above explanations and discussion.

7.1 Minimal standards

-Methods used should be described in a way so that others can replicate the study as far as possible.

-Explain why the research area and local participants are of interest and relevant for the specific research question.

-Description of study site and local participants: Along with the overall health care options, the epidemiologic and ethnographic background, the rationale of people's health seeking behaviour can be put in perspective and accommodates the research questions.

-Describe the selection of respondents, and provide basic information about age and gender.

Accepted manuscript

-Method of information collection, e.g., informal, unstructured, semi-structured interviews, focus groups, freelist questions, questionnaires, participant observation should be specified. In addition who conducted the interview and which language was used during the conversation? What kinds of questions were asked?.

-Explain criteria and methods used for establishing therapeutic use-categories.

-Document the legal right to collect and transport plants or voucher specimens. For studies involving traditional knowledge a written permit from local or community councils or similar entities is also required.

-Specify source of accepted species and family names through nomenclature standards (e.g., http://mpns.kew.org/mpns-portal or http://www.theplantlist.org/).

-Voucher specimens should whenever possible be deposited in an officially recognized herbarium that is located at a recognized institution and committed to the long-term maintenance of its collection.

-For reporting primary data and in order to use field-data as a guide for laboratory studies it would be important to know how many local participants mentioned/cited each of these specific uses. This means you should report the frequency of citation (or use-reports) per species, drug, application and use (and not number of citations per plant taxon or relative data).

(See also rules of 5 and journal checklist)

7.2 Recommendations for best practice

-Address specific research questions and contribute to disciplinary debates, and conceptual frameworks that can advance the field and relate to contemporary issues in both scientific and public spheres.

-Working with local people on an equal partnership basis including collaboration and knowledge transfer.

-Participant observation is used to collect contextual information and for verification of interview results.

-The ideal field study covers a full floral, agricultural and cultural cycle and therefore would last at least a year.

-It's a good practice to interview participants more than once at different periods of the year to capture seasonal differences in illnesses, availability of plant remedies and market inventories.

-If the research project and the local situation allows, it might be good practice

Accepted manuscript

to document the whole *materia medica* or medicinal flora of a community or a population, not just parts thereof.

-Consider the influence of globalization and the impact of popular media and scientific communications on local plant use and knowledge.

-Specify means for dissemination of research results, outreach to participants, and access and benefit sharing arrangements (ABS). This may include outreach publications, local databases and knowledge exchange.

-Include links to high-resolution scans (or digital photos) of the herbarium vouchers in either the main manuscript or as supplementary data.

-To safeguard the intellectual property of study participants we suggest that every manuscript should include a statement similar to the following: "All work conducted was carried out under the stipulations of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. The right to use and authorship of any traditional knowledge of all participants is maintained, and any use of this information, other than for scientific publication, does require additional prior consent of the traditional owners, as well as a consensus on access to benefits resulting from subsequent use."

Accepted manuscript

ACCEPTED MANUSCRIPT

References

Alexiades, M.N., 1996. Selected Guidelines for Ethnobotanical Research: A Field Manual. Bronx, NY: New York Botanical Garden.

Baker, M., 2016. 1,500 scientists lift the lid on reproducibility. Nature 533, 452–454.

Bennett, B.C., Balick, M.J., 2014. Does the name really matter? The importance of botanical nomenclature and plant taxonomy in biomedical research. J. Ethnopharmacol. 152, 387–392.

Bernard, H.R., 2011. Research Methods in Anthropology – Qualitative and Quantitative Approaches. Fifth Edition. UK: Altamira Press.

Berlin, B., 1973. Folk systematics in relation to biological classification and nomenclature. Annu. Rev. Ecol. Syst. 4, 259–271.

Berlin, E.A., Berlin, B., 1996. Medical ethnobiology of the highland Maya of Chiapas, Mexico: The gastrointestinal diseases. Princeton: Princeton University Press.

Berlin, E.A., Berlin, B., 2005. Some field methods in medical ethnobiology. Field Methods, 17, 235–268.

Bridson, D., Forman, L., 2013. The herbarium handbook. Third edition. Kew: Royal Botanic Gardens.

Cook, F.E.M., 1995. Economic Botany Data Collection Standard. Prepared for the International Working Group on Taxonomic Databases for Plant Sciences (TDWG). Kew Royal Botanic Gardens, Kew.

Convention on Biological Diversity (CBD). Online: https://www.cbd.int Accessed February 15, 2017.

Convention on Biological Diversity. The Nagoya Protocol. Online: <https://www.cbd.int/abs/> Accessed February 15, 2017.

Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Online: <https://www.cites.org/> Accessed February 15, 2017.

Cotton, C.M., 1996. Ethnobotany. Principles and Applications. John Wiley & Sons.

Cunningham, A., 2001. Applied Ethnobotany: People, Wild Plant Use and Conservation. People and Plants Conservation Manuals. London: Earthscan.

Dudney, K., Warren, S. Sills, E., Jacka, J., 2015. How study design influences the ranking of medicinal plant importance: a case study from Ghana, West Africa. Econ. Bot. 69, 306–317.

Accepted manuscript

Gamborg, C., Parsons, R., Puri, R.K., Sandøe. P., 2012. Ethics and research methodologies for the study of traditional forest-related knowledge. In Traditional Forest-Related Knowledge: Sustaining Communities, Ecosystems and Biocultural Diversity, edited by J.A. Parrotta and R.L. Trosper. World Forests, Volume 12, 535–562. New York: Springer.

Gentry, A.H.,1993. A Field Guide to the Families and Genera of Woody Plants of Northwest South America. With Supplementary Notes on Herbaceous Taxa. Chicago: University of Chicago Press.

Gertsch, J., 2009. How scientific is the science in ethnopharmacology? Historical perspectives and epistemological problems. J Ethnopharmacol. 122, 177–183.

Headland, T.H., 1990. Introduction: A dialogue between Kenneth Pike and Marvin Harris on emics and etics. In: Headland, T., Pike, K., Harris, H. (Eds.), Emics and Etics: The Insider/Outsider Debate, pp. 13–27. Newbury Park: Sage.

Heinrich, M., Edwards, S., Moerman, D.E., Leonti, M., 2009. Ethnopharmacological field studies: A critical assessment of their conceptual basis and methods. J Ethnopharmacol. 124, 1–17.

Heinrich, M., Lardos, A., Leonti, M., Weckerle, C., Willcox, M., 2017. Best Practice in Research: Consensus Statement on Ethnopharmacological Field Studies – ConSEFS. In revision

Howard, P.L., (ed.), 2003. Women & Plants. Gender Relations in Biodiversity Management & Conservation. London: Zed Books.

International Classification of Primary Care (ICPC): http://www.who.int/classifications/icd/adaptations/icpc2/en/ (accessed 16.03.2015).

International Society of Ethnobiology. Code of Ethics. http://www.ethnobiology.net/what-we-do/core-programs/ise-ethics-program/code-of-ethics/

Jäger, A.K., 2005. Is traditional medicine better off 25 years later? J. Ethnopharmacol. 100, 3–4.

Kadam, P., Bhalerao. S., 2010. Sample size calculation. Int. J Ayurveda Res. 1, 55–57.

Leonti, M., Weckerle, C.S., 2015. Quantitative and Comparative Methods in Ethnopharmacology. Heinrich M., Jäger A.K. (eds.) Ethnopharmacology. Ltd. Published by John Wiley & Sons.

Martin, G., 1995. Ethnobotany: A Methods Manual. Chapman and Hall.

Accepted manuscript

McClatchey, W., 2006. Improving the Quality of International Ethnobotany Research and Publications. Ethnobot. Res. Appl. 4:1–9.

Medicinal Plant Names Services Portal (http://mpns.kew.org/mpns-portal)

Newing, H., 2011. Conducting research in conservation. A social science perspective. New York: Routledge.

Pfeiffer, J.M., Butz, R.J., 2005. Assessing cultural and ecological variation in ethnobiological research: the importance of gender. Journal of Ethnobiology 25, 240–278.

Puri, R.K., 2011. Documenting Local Environmental Knowledge and Change. In Conducting Research in Conservation: A Social Science Perspective, ed. Helen Newing. Pp. 126–152. London: Routledge.

Puri, R.K., 2013. Transmitting Penan basketry knowledge and practice. In Understanding cultural transmission: a critical anthropological synthesis, eds. Ellen, R.F., S. Johns and S. Lycett. Oxford: Berghahn Books.

Reyes-García, V., Broesch, J., Calvet-Mir, L., Fuentes-Peláez, N., McDade, T.W., Parsa, S., Tanner, S., Huanca, T., Leonard, W.R., Martínez-Rodríguez, M.R., and TAPS Bolivian Study Team, 2009. Cultural Transmission of Ethnobotanical Knowledge and Skills: An Empirical Analysis from an Amerindian society. Evol. Hum. Behav. 30, 274–285.

Reyes-Garcia, V., 2013. Introduction to Special Section On the relations between schooling and local knowledge. Learning and Individual Differences 27, 201–205.

Rivera, D., Allkin, R., Obón, C., Alcaraz, F., Verpoorte, R., Heinrich, M., 2014 What is in a name? The need for accurate scientific nomenclature for plants. J Ethnopharmacol. 152, 393-402.

Staub, P.O., Geck, M.S., Weckerle, C.S., Casu, L., Leonti, M., 2015. Classifying diseases and remedies in ethnomedicine and ethnopharmacology. J. Ethnopharmacol. 174, 514–519.

Towns, A. M., Quiroz, D., Guinee, L., de Boer, H., van Andel, T., 2014. Volume, value and floristic diversity of Gabon's medicinal plant markets. J. Ethnopharmacol.155, 1184–1193.

Trotter, R.T., Logan, M.H., 1986. Informant consensus: A new approach for identifying potentially effective medicinal plants. In N. Etkin, ed., Plants in indigenous medicine and diet: Biobehavioral approaches, pp. 91–112. Bedford Hills, New York: Redgrave Publishing.

Van Andel, T., Myren, B., Van Onselen, S., 2012. Ghana's herbal market. J. Ethnopharmacol. 140, 368–378.

Accepted manuscript

Verpoorte, R., 2012. Primary data are the basis of all science! J. Ethnopharmacol. 139, 683–684.

Watt, T.A., McCleery, R.H., Hart, T., 2007. Introduction to Statistics for Biology, Third Edition, New York. Chapman & Hall / CRC.

WHO (World Health Organization) 2013. WHO traditional medicine strategy: 2014-2023. Geneva: WHO Press. Online at http://apps.who.int/iris/bitstream/10665/92455/1/9789241506090_eng.pdf Accessed: October 21, 2016.

Willcox, M.L., Graz, B., Falquet, J., Diakite, C., Giani, S., Diallo, D., 2011. A "reverse pharmacology" approach for developing an anti-malarial phytomedicine. Malar J. 10 Suppl 1:S8.

World Intellectual Property Organization (WIPO) TK Documentation Toolkit (https://www.cbd.int/tk/wipo.shtml).

Zent, S., Maffi, L., 2008. 'Final Report on Indicator No. 2: Methodology for Developing a Vitality Index of Traditional Environmental Knowledge (VITEK) for the Project “Global Indicators of the Status and Trends of Linguistic Diversity and Traditional Knowledge.” Terralingua. Online at: <http://terralingua.org/wp-content/uploads/2015/07/VITEK_Report.pdf> Accessed February 15, 2017.

Accepted manuscript